TOXICITY OF A HYDROGEN PEROXIDE-BASED DECONTAMINATION SOLUTION (DECON GREEN) IN WATER AND SOIL EXTRACTS

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ABSTRACT

The U.S. Army has developed a hydrogen peroxide-based decontaminating solution, Decon Green (DG). The components of the decon solution are less hazardous to the end-user and the environment than standard decon solutions that are in the current inventory. Toxicity studies were conducted as direct amendments of DG into water, and into soil. Aquatic organisms were exposed directly to water amended with DG. Soils amended with DG were subjected to an Adapted Toxicity Characteristic Leaching Procedure (ATCLP) in order to produce exposure solutions. In addition, we performed corresponding toxicity investigations using DG solution that was allowed to age. Overall, *Vibrio fischeri* was less sensitive to DG than *D. magna* and *C. dubia* by approximately one order of magnitude. Provisional data indicate that the 5-min EC_{50} for *Vibrio fischeri* was 200 ppm (vol/vol), and the 48-hr EC_{50} for *D. magna* and *C. dubia* were 26 and 25 ppm (vol/vol), respectively; IC_{50} for *C. dubia* exposed to DG directly amended into water was 28 ppm (vol/vol), while the IC_{50} for *C. dubia* exposed to extracts of soils amended with GD was 2400 ppm (mass/mass; in soil). Based on acute aquatic toxicity, DG was substantially less toxic to these organisms than traditional decontamination solutions.

1. INTRODUCTION

The U.S. Army has developed a hydrogen peroxide-based decontaminating solution, Decon Green (DG), effective against chemical as well as biological agents (Wagner et al., 2002). The components of the hydrogen peroxide-based decon solution are less hazardous to the end-user than decon solutions currently in the inventory [Decontaminating Solution (DS-2), and Decontaminating Agent: Multipurpose (DAM)] (Haley et al., 1994a, Haley et al., 1994b). A component of DS-2 (ethylene glycol monomethyl ether, EGME) has been determined to cause birth defects, fetotoxicity and bone marrow complications in laboratory animals (Sigma Aldrich, 1989). Both DS-2 and DAM contain a component that is highly corrosive, creating compatibility problems and additional hazards to the end user and the environment. Safety data sheets and open literature publication exist on the individual components of DG. However, environmental information on the mixture is lacking. Using the information provided on individual components can only provide speculation on environmental effects, and does not account for possible synergistic or antagonistic interactions. The studies described in this report will provide baseline toxicity screening levels on both neat, and aged DG solutions. This information can be used in the preparation of Environmental Assessments (EA), needed before new candidate materials can be fielded. This study does not address the possible change in toxicity due to the method of deployment or property changes resulting from agent neutralization.

The DG formulation consist of potassium molybdate, potassium carbonate, hydrogen peroxide, propylene carbonate, and Triton X-100®. Since a principal component of the DG mixture is hydrogen peroxide (30% by volume), it was assumed that the primary toxicity of DG would be reduced and possibly eliminated after relatively short exposure or contact with soil. Therefore toxicity studies were conducted as direct fresh amendments into water, and into soil. Aquatic organisms were exposed directly to the water amended with DG. Soils (Sassafras Sandy Loam) amended with DG were subjected to an Adapted Toxicity Characteristic Leaching Procedure (ATCLP) in order to produce exposure solutions. In addition, we performed corresponding toxicity investigations using DG solution that was allowed to age with intermittent stirring until visible bubbles from hydrogen peroxide activity had ceased.

Although a number of aquatic organisms are available for short term testing, we selected the marine luminescent bacteria *Vibrio fischeri*, and fresh water crustacean *Daphnia magna* for conducting short term (5 minute, and 48 hour respectively) acute toxicity assays. The fresh water crustacean *Ceriodaphnia dubia* was selected as the

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primary test organism, used in determining the effects on reproduction after seven days of exposure.

2. RESULTS

Bubbles from the hydrogen peroxide off-gassing made transfer of fresh samples of DG difficult. Pipettes had to be rinsed several times with DG to reduce off-gassing in order to maintain desired volume for transfer. After aging 16-17 days, the DG solution had separated into two distinct layers. The top layer being clear, and the bottom layer pale clear-yellowish in color. After aging 30 days the solution was clear with no color, and layering that was difficult to distinguish (Figure 1).

Figure 1. Aged Decon Green after; a. 30 minutes, b. 7 days, and c. 30 days.

a b c

DG was approximately two orders of magnitude less toxic to *Vibrio fischeri* than DAM, and one order of magnitude less toxic than DS-2. Decon Green was two orders of magnitude less toxic to *D. magna* than DAM, and approximately 1.5 times less toxic than DS-2. Provisional data indicate that the 5-min EC_{50} for *Vibrio fischeri* was 200 ppm (vol/vol), and the 48-hr EC_{50} for *D. magna* and *C. dubia* were 26 and 25 ppm (vol/vol), respectively; IC_{50} for *C. dubia* exposed to DG directly amended into water was 28 ppm (vol/vol), while the IC_{50} for *C. dubia* exposed to extracts of soils amended with GD was 2400 ppm (mass/mass; in soil). After 16 days of aging, the DG solution the toxicity to *Vibrio fischeri* was reduced one order of magnitude. We are currently investigating reproductive effects on *C. dubia* using aged DG.

3. CONCLUSION

Based on acute aquatic toxicity, neat DG is less toxic to *Daphnia magna* and *Vibrio fischeri* than DS-2 and DAM decon solutions. Provisional results show the toxicity of DG to *Vibrio fischeri* decreases over time. Using the Chemical Scoring System for Hazard and Exposure Identification (O'Bryan et al., 1988), the overall aquatic toxicity score for DG was rated 5 (slightly toxic to aquatic organisms).

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